COMPARISON OF CAPTURE-MELTED AND UNMELTED STARDUST COMETARY PARTICLES: PRELIMINARY TEM ANALYSES. C. H. van der Bogert[1] and T. Stephan[2], [1]Westfälische Wilhelms-Universität Münster, Institut für Planetologie, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (vanderbogert@uni-muenster.de), [2]University of Chicago, Department of the Geophysical Sciences, 5734 South Ellis Ave, Chicago, IL 60637, USA (tstephan@uchicago.edu).

Introduction: Analyses of NASA Stardust samples provide an unprecedented view of the mineralogy of a known comet, 81P/Wild 2. The information gleaned from these samples so far has challenged us to reassess and modify models of early solar system processes and the formation of comets. Indeed, the most important results thus far show that Wild 2 is composed of an unequilibrated assortment of minerals exhibiting a wide-range of formation conditions [1, 2]. The unexpected presence of minerals that form at high temperatures necessitates that materials from a wide cross-section of the protosolar nebula were mixed into the regions of space where Wild 2 formed [e.g., 1, 2]. It was generally expected that a greater proportion of the cometary material would be presolar in origin, but thus far, only one grain of confirmed presolar origin has been identified in the Stardust samples [3].

The cometary particles least affected by their impact into the aerogel capture medium were those particles that survived the initial impact and traveled deepest into the aerogel, i.e., "terminal particles". These particles were likely larger and more coherent, thus more resistant to impact processing. However, the materials present in the margins of the bulbous impact cavities can also provide information about Wild 2. Much of this material was melted upon impact into the aerogel, but maintains an overall CI-like composition (c.f., [5, 6]). The purpose of this study is to compare capture-melted and terminal particles.

Methods: As part of an ongoing collaborative effort, Stardust cometary particles from both capture-melted materials and terminal particles are being analyzed using a two-pronged approach. First, high sensitivity elemental measurements are made using time-of-flight secondary ion mass spectrometry (TOF-SIMS) [7]. Second, mineralogical analyses of very high spatial resolution are made via transmission electron microscopy (TEM) [this contribution]. TEM analyses are always performed second, in order to minimize possible sample contamination for TOF-SIMS analyses.

Samples: The samples presented here include materials from both the edges of impact tracks and terminal particles (Fig. 1), representing both capture-melted and relatively pristine cometary material.

Capture-melted particles. Samples extracted from the areas of impact tracks near the entry point into the aerogel are frequently mixed composition glasses that likely represent cometary material melted and mixed with aerogel during the capture process, for example, C2054,0,35,16,0 and C2054,0,35,24,0 (Figs. 1, 2)[5]. TEM grids C2054,0,35,16,9 #44 and C2054,0,35,24,5 #19 were both analyzed with TOF-SIMS and TEM.

Both samples are composed mainly of silica-rich glass with varying concentrations of Fe, Mg, and Si as determined by both TOF-SIMS and EDX analyses (Fig. 2, [6, 8]). These glasses contain finely dispersed FeNi and FeS spherules (Fig. 3a), which melted during the capture process and subsequently recrystallized. The compositions and textures of these materials are grossly homogeneous, generally reflecting solar abundances of both major and minor elements [5, 8]. The exceptions are probable contaminants. For example, individual TiO_2 grains adjacent to C2054,0,35,16,9 #44 (Fig. 3b), identified using EDX analysis, were likely present in the original aerogel. Calcite contamination was also observed in some samples [6, 9]. These contaminants might be concentrated along the margins of the entry cavities by the outward movement of aerogel during the impact. This could explain why we have thus far observed contaminants in more along-track samples than terminal particles, and why some contaminants have aerogel coatings.

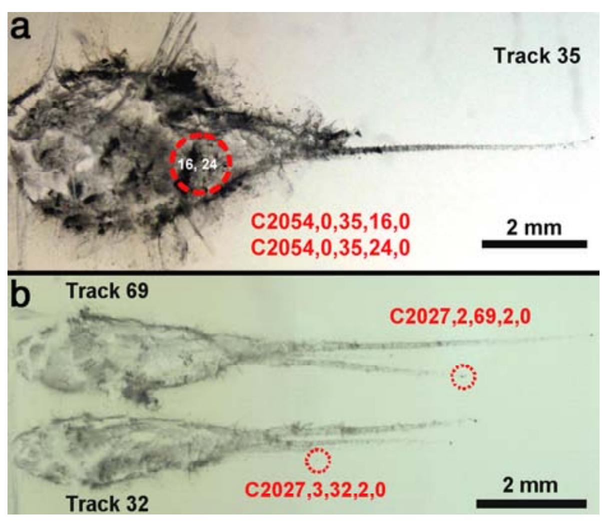

Figure 1. (a) *Stardust cometary aerogel cell C2054, impact track 35. The investigated particles (TEM grids C2054,0,35,16,9 and C2054,0,35,24,5) are both from the margin of the bulbous entry cavity.* ***(b)*** *Stardust cometary aerogel cell C2027, impact tracks 32 and 69. The investigated particles (TEM grids C2027,3,32,2,6 and C2027,2,69,2,5,) are both terminal particles.*

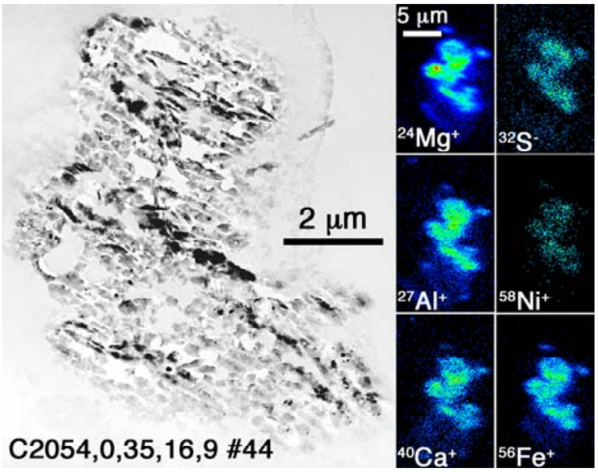

Figure 2. *TEM bright field image of cometary dust sample C2054,0,35,16,9 #44 on amorphous carbon film and selected TOF-SIMS secondary ion images [8].*

Terminal particles. Terminal particles represent materials that survived capture with minimal impact effects. Two terminal grains (C2027,2,69,2,5 #25 and C2027,3,32,2,6 #20) analyzed with TOF-SIMS in a companion study [7], are currently being analyzed using TEM techniques. Both particles exhibit an external coating of compressed aerogel. The margins of particle C2027,3,32,2,6 #20 exhibit small areas of glassy material with finely dispersed, submicron metallic blebs, similar to the capture-melted material analyzed previously. Both samples are composed largely of crystalline mineral phases, in stark contrast to the capture-melted particles. TOF-SIMS analyses suggest the presence of pyroxene and a Ca,Al-rich phase, possibly anorthite in sample C2027,2,69,2,5 #25 [7] (Fig. 4).

Discussion: Differences between capture-melted and terminal particles may partly owe to the capture process itself. The capture process caused sorting of the particles, so that friable, porous particles were decelerated faster and were more likely to melt and mix with melted aerogel, while coherent, larger particles penetrated deeper into the aerogel. Thus, the compositions exhibited by the capture-melted material, may represent the composition of fine cometary matrix material, while the terminal particles represent materials that were also larger grained while within Wild 2. Do these two types of materials have the same overall compositions? If they represent distinct cometary materials, they may reveal different aspects of cometary formation. Thus, a fuller understanding of the effects of aerogel capture on cometary particles is necessary both from laboratory experiments (e.g., [10]) and current studies of Stardust samples. Studying both the effects of capture and their implications for the formation of comets are motivations for the current study.

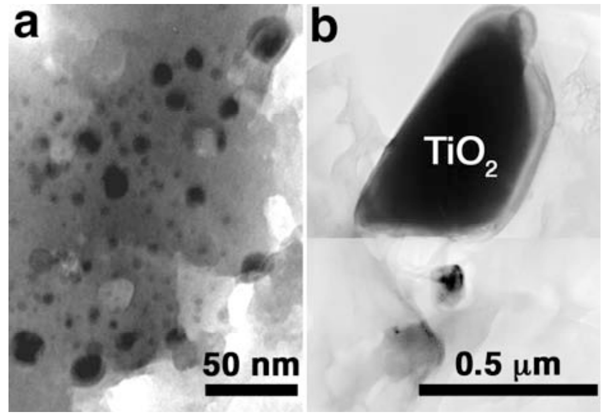

Figure 3. (a) *Tiny FeNi and FeS blebs dispersed in silica-rich glass with varying Fe and Mg composition in capture-melted particle C2054,0,35,24,0 (TEM grid 5, #19). Similar textures were also present in other capture-melted cometary particles.* ***(b)*** *TiO_2 contaminant grains in aerogel adjacent to the sample in Fig. 2.*

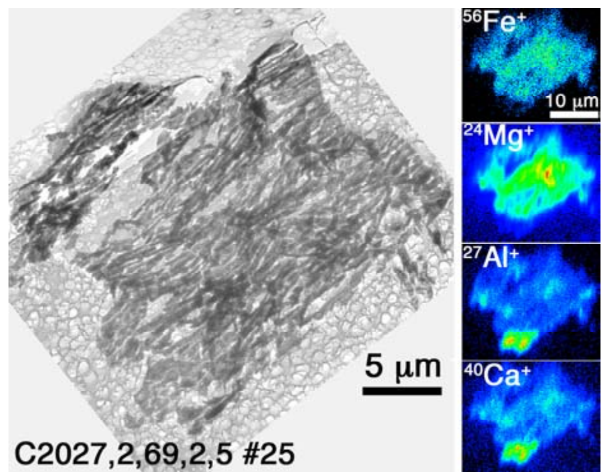

Figure 4. *TEM bright field image of cometary dust sample C2027,2,69,2,5 #25 on amorphous, lacy carbon film, and selected TOF-SIMS secondary ion images as reported in a companion abstract [7].*

References: [1] Zolensky M. et al. (2006) *Science 314*, 1735-1739. [2] Brownlee D. et al. (2006) *Science 314*, 1711-1716. [3] McKeegan K. et al. (2006) *Science 314*, 1724-1728. [4] Hörz F. et al. (2006) *Science 314*, 1716-1719. [5] Stephan T. (2007) *Space Sci. Rev.,* DOI 10.1007/s11214-007-9291-2. [6] van der Bogert et al. (2007) *Meteoritics & Planet. Sci., 42,* A153. [7] Stephan T. and van der Bogert C. (2008) *LPS XXXIX,* Abstract #1508. [8] Stephan T et al. (2008) *Meteoritics & Planet. Sci.,* in press. [9] Wirick S. et al. (2007) *LPS XXXVIII*, Abstract #1534. [10] Kearsley A. et al. (2007) *Meteoritics & Planet. Sci., 42,* A80.

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